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Dear John:

I am writing this letter to advise you unofficially, yet in somewhat detailed form, of several situations which we have discussed personally and over the telephone in the past few months. Primarily, my discussion here will be limited to new problems being faced which were not possible to predict last December. As you recall, a request for additional funds was submitted in December. This request was based on cost-to-complete estimates as of December 1st.

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At that time, the cost estimate was considered adequate for all remaining work. This estimate was made with our best estimate of design-time required, even though the precise design approach was not in all cases defined. Since that time, our schedule has not been fully realized due to unforeseen problems with parts procurement and design limitations. There is some evidence that additional funds beyond those requested in December may be required due to several considerations which were not apparent at the end of last year; these considerations include the following:

1) The estimated cost-to-complete on December 1, 1959, presupposed the addition of an engineer experienced in photo-transmission system design. Owing to the pressure of other commitments, this engineer was not available on full-time basis until the first of March. Consequently, the schedule for completion of the first photo-transmission system assembly was set forward approximately two months. Additional engineering personnel were phased into the portion of the work to minimize this production lag with consequent increase in cost. The delay in the assembly of the first item will cause additional technician and engineering time for the system tests, since the completed system cannot be tested at one time if present schedules are to be met. In efforts to prevent additional costs, certain components of the photo-transmission system, such as the deflection amplifier and sweep attenuator, have been designed from knowledge of the earlier contract by engineers assigned in other areas. This has caused delays in the completion of design and

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assembly to the program control system and the modifications of this equipment in the light of later design have also been a source of additional cost.

2) The digital circuitry design and fabrication have required an additional month because of the use of a 5mc clock frequency (a 1mc clock frequency was used on the engineering model --- a clock frequency of 100kc is used in most digital computers), requiring the latest transistor circuitry, and because of the difficulties in debugging this type of high-frequency counting circuitry. The high-frequency counter design has also required additional time to eliminate the relay registers previously used and to employ transistor registers for memorizing tape data. This has required an extra ten-man weeks of engineering time.

3) The clock-frequency multiplier was designed on the basis of information received from [] on their optical disk characteristics. Interpretation of information was in error and consequently we have had to modify multipliers that had been designed and also add another stage of multiplication. This has caused an extra week of engineering technician and shop time.

The higher counting frequency encountered in the use of the [] disks introduced a problem not previously existing. The highest counting speed with photo-transistors exceeded the alpha cutoff available from such components and redesign of the photo-transistor circuitry was required to accommodate the higher frequency. The number of components involved required additional effort in making plug-in assemblies for this circuitry. This required an additional three weeks of design time and two weeks of technician time, together with an addition in fabrication time and parts costs.

4) The conventional servo-amplifier designed for use with the photo-multiplier drive assembly has proved in test to be inadequate. The solution to this problem required the design of a new servo amplifier (for which patents will be applied) with a consequent increase in design time and test time. This problem has accounted for four weeks of engineering time, three weeks of technician time, and additional parts and assembly cost. The urgency of this new approach to the problem has required that personnel assigned to program control circuitry be removed from that task temporarily, and therefore represented a delay in the program control development of one month.

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5) Since an engineer has been assigned to photo-transmission design, no difficulties have occurred in this area. The principal problems have been new requirements for matching of the design equipment to the remainder of the system. Special shielding, grounding, and decoupling requirements have been particularly aggravating. No delay has been created from this factor to date, but it is anticipated that it will prolong the cable assembly and system-test phases.

6) The digital circuit design has proved to be much more complex than anticipated. Although there has been no resulting design problem, their high-component density has required more time than estimated. Considerable methods improvement in assembly procedure has recently been made, and original time estimates for each board will be approached; however, this factor will account for an additional three man-months of assembly labor.

7) Design and assembly time had been expected to be negligible for the several power supplies that were purchased. The modification required to fit the power supply control system was greater than anticipated by one week for each of eight power supplies. The principal increase in time, however, was caused by special mechanical design required to mount the equipment in the console. It was not possible to foresee this problem because both the equipment rack and the power supplies were purchased items where the minor physical details creating the conflict could not be ascertained from information supplied by the manufacturers. Additional work has resulted in a more compact assembly, using a double-equipment rack rather than a triple-equipment rack. It is felt that this additional cost has been justified by product improvement, even though that product improvement has not been the direct cause of the increased costs.

8) In the process of assembling the cabinets for the first model, several assembly problems have occurred that had not previously been anticipated. Individually, these have been minor considerations, but cumulatively they have accounted for an extra month and one-half of design time and an extra month of technician time. The original estimates of shop time required for fabrication were under-estimated by 25 per cent. The additional cost of assembly has also been a substantial part of the total cost increase.

9) Since fabrication has been completed on items of the first unit, several complications have been indicated in system-test time. System testing of the first unit can require more digital circuit debugging as well as elimination of cross-coupling in circuitry.

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10) Since the completion of the structure of the reader and printer, resonance problems have been the source of some experiment and study. The addition of local structural damping has required more labor than anticipated.

I hope that the above information will be useful to you and will help you to lay any groundwork which might be required if it should later become necessary for us to initiate action to obtain additional funds. We are still attempting to fit all the remaining work into the estimated budget. However, at the earliest moment that this course becomes clearly impractical, we shall send official notice to you that additional funds will be required.

Very truly yours,

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